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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/823,364	04/12/2004	Steven C. Shannon	8756/ETCH/DICP	4844

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EXAMINER	
ANGADI, MAKI A	
ART UNIT	**PAPER NUMBER**
1765	

DATE MAILED: 10/31/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

C

Office Action Summary	Application No. 10/823,364	Applicant(s) SHANNON ET AL.	
	Examiner Maki A. Angadi	Art Unit 1765	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 05 September 2006.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-14 and 33-46 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-14 and 33-46 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

Response to Amendment

Examiner acknowledges the amendments to claims 1-14 and 33-39 and addition of new claims 40-46

DETAILED ACTION

Claim Rejections - 35 USC § 103

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

3. Claims 1-3, 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Demaray et al. (US 2003/0127319).

The reference of Demaray describes a method of controlling the deposition and etching characteristics of plasma on a semiconductor substrate

(16) (page 3, paragraph 0025, page paragraph 0048/0049) in a processing chamber using a dual frequency RF source comprising:

Supplying a first (14) and second (15) RF signals to an electrode, wherein an interaction between the first and second signals is used to control at least the plasma density, ion bombardment and electron acceleration of plasma formed in the processing chamber (page 5, paragraph 0043).

It is noted that Demaray's method is suitable for optical devices, however, Demaray cites "target (12) is composed of wide band-gap semiconductor materials" (page 2, paragraph 0024) and a semiconductor substrate (16) (page 3, paragraph 0025), in addition, one of ordinary skill in the art would know that PVD processes are conventionally used in semiconductor manufacturing.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to process semiconductor substrates for opto-electronic applications using the method of Demaray because Demaray discloses typical substrates are semiconductor wafers. One of ordinary skill in the art would be motivated to form opto-electronic semiconductors in order fabricate opto-electronic transducers in combination with integrated optical devices with good control of refractive index.

As to claim 2, Demaray discloses when power is applied a sheath is formed, the sheath serves to accelerate the ions (page 5, paragraph 0047), and dual frequency affects (or modulate) the ions and electrons acceleration (page 5,

paragraph 0043), which reads on applicant's instant claim where the dual frequency causes a sheath modulation.

As to claim 3, Demaray discloses "The high frequency accelerates electrons in the plasma but is not as efficient at accelerating the much slower heavy ions in the plasma. Adding the low frequency RF power causes ions in the plasma to bombard the film being deposited on the substrate" (page 7, paragraph 0043). One of ordinary skill in the art would know that ion bombardment strong enough to sputter must be generated by a strong self-biasing sheath in the plasma.

As to claim 10, Demaray uses dual frequency for the target to improve film characteristics as well as film uniformity, which is an attribute of power distribution uniformity (page 2, paragraph 0023).

As to claims 40-46, Demaray discloses the electrode (19) beneath a substrate (16) support surface in the etch chamber (paragraphs 0024 and 0025), wherein the electrode is a cathode (12) (paragraph 0024), etching a substrate disposed on the substrate support (paragraph 0048), wherein the electrode is disposed beneath a substrate support in the etch chamber (Fig.1a).

Claim Rejections - 35 USC § 103

4. Claims 4-9, 11, 12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Demaray et al. (US 2003/0127319) as applied to claims 1-3,

10 above, and further in view of Georgieva et al. (Journal of Applied Physics, V. 94, No. 6, Sept. 15 2003, pages 3748-3756).

It is noted that Demaray is silent about details of the ion energy distribution function (IEDF).

As to claim 4, the reference of Georgieva discloses, depending on the gas used, the IEDF varies from a broad distribution (figure 8) to a peaked well-defined distribution depending on the specific ions, pressure, power level and frequency. Applicant has not defined any scale for the energy spread, type of ions, power levels or frequency.

Therefore, it would appear that with proper choice of the above parameters, one of ordinary skill in the art would be able to obtain an IEDF of any desired shape as taught by Georgieva including a broad ion energy distribution for the first frequency and a peaked, well defined energy distribution for the second frequency as illustrated by Georgieva in figure 8 and in the Ion Energy Distribution section on page 3754.

As to claim 5, Georgieva teaches a detailed model on how ions respond the excitation frequency (cycle time, period) in the ion sheath. Applicant does not define any plasma parameter used for claim 5.

Therefor it would appear that one of ordinary skill in the art would be able to use the teachings of Georgieva in order to obtain a plasma wherein a first RF signal has a cycle time that is larger than the transit time of an ion in the sheath, and wherein the second RF signal has a period that is equal to or greater than

the transit time of an ion in the sheath since a processing plasma usually includes a multitude of ions (as illustrated by Georgieva) a combination of any two frequency is likely to yield one type of ions having a small mass and a transit time in the sheath that is smaller than a first frequency cycle time, and yield other ions, heavier, with a transit time nearly equal to the second frequency period. Applicant has not shown unexpected results associated with the ions transit time in the sheath as described in the instant claim.

As to claim 6, a peak-to-peak voltage is usually defined in the case of one frequency as being the voltage between the highest value to the lowest within on cycle, It would appear that a "peak-to-peak" sheath voltage needs to be defined in the case where two frequencies are superposed. The reference of Demaray teaches " A theoretical model of the mechanism by which substrate bias operates, has been put forward by Ting et al. (J. Vac. Sci. Technol. 15, 1105 (1978)). When power is applied to the substrate, a so-called plasma sheath is formed about the substrate and ions are coupled from the plasma. The sheath serves to accelerate ions from the plasma" (page 5, paragraph 0047). The dual frequency powers will therefor control the sheath or self-biased DC potential.

As to claims 7, 8, Demaray clearly cites the effect of each frequency on the ions (see rejection to claim 1 above), It is expected that the applied power for each frequency will have an effect on their interaction and one of ordinary skill in the art would expect that the ratio of the powers can be used to tune the energy distribution of the ions since Demaray teaches the effect of the frequencies on

the ions. The higher frequency controls electron/ion density the lower frequency controls ion bombardment (through the sheath or DC potential) according to Demaray.

As to claim 9, Demaray discloses supplying a third RF signal (18) to a second electrode (under (17)) to form the plasma.

As to claims 11, 12 it is noted that Demaray is silent about special uniformity profiles for the RF signals. The reference of Georgieva shows that the spatial electric field distribution (electric fields are related to plasma excitation in a plasma) depends on the excitation frequency (figures 2 and 3) while the electric fields remain in the same order of magnitude, it is clear that these figures show different spatial distributions for different frequencies.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to expect the first and second RF signals to provide similar excitation with different spatial distribution as taught by Georgieva. Clearly Georgieva shows the varying effect on the power distribution in the plasma from the two RF signals (figure 3), and use superposition to obtain a uniform characteristic of the processing plasma because plasma uniformity is necessary for processing uniformity. One of ordinary skill in the art would have been motivated to use superposition of two complementary energy distributions in order to obtain a combined uniform energy distribution desirable for uniform processing.

Claim Rejections - 35 USC § 103

5. Claims 13, 33 are rejected under 35 U.S.C. 103(a) as being unpatentable over Demaray et al. (US 2003/0127319) in view of Georgieva et al. (Journal of Applied Physics, V. 94, No. 6, Sept. 15 2003, pages 3748-3756) as applied to claims 4-9, 11, 12 above, and further in view of Lieberman et al. (Plasma Sources Sci. Technol., 11 (2002) pages 283-293).

It is noted that Demaray is silent about selecting the first and second RF signals to produce a flat power distribution.

The reference of Georgieva teaches spatial distribution is different for different frequency, and the reference of Lieberman teaches radial plasma electric field distribution is different for different frequencies as well (figure 8 and 10).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Demaray to obtain even higher uniformity by selecting the proper parameters for the plasma and combining complementary first and second frequencies energy distributions to obtain an net radial power distribution that is substantially uniform because the reference of Lieberman teaches how spatial power distribution depends on frequency. One of ordinary skill in the art would be motivated modify the method of Demaray to include the teachings of Lieberman in order to obtain a highly uniform process area which is desirable for plasma processing in general by combining two frequencies with complementing energy or power distributions.

As to claim 33, Demaray discloses 13.56 MHz, 100 to 400 KHz (page 5, paragraph 0043) and 2 MHz (page 11, paragraph 0086) are conventionally used in the art. It is noted that Demaray fails to disclose 13.56 MHz and 2 MHz on the same electrode.

The references of Georgieva (27 MHz and 2 MHz) and Lieberman (13.56 MHz and 40.7 MHz) teach the benefits of dual frequency are not limited to mixing 13.56 MHz and 100 to 400 KHz on the same electrode, but frequencies can be mixed across a wider frequency spectrum.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Demaray to obtain higher uniformity by mixing 13.56 MHz and 2 MHz on the same electrode for applications not requiring high ion bombardment because Demaray teaches the highest ion bombardment is obtained at the lowest frequency and Georgieva along with Lieberman teach frequency mixing has an effect on process uniformity. One of ordinary skill in the art would have been motivated use the teachings of the three references above to arrive at a proper frequency combination while utilizing commercially and readily available RF power generators. One who is skilled in the art would be motivated to optimize through routine experimentation of frequency mixing using commercially available RF power supplies. See MPEP § 2144.05 (II)(B).

Claim Rejections - 35 USC § 103

6. Claim 14 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dhindsa et al. (US 2003/0148611) in view of Demaray et al. (US 2003/0127319), Georgieva et al. (Journal of Applied Physics, V. 94, No. 6, Sept. 15 2003, pages 3748-3756) and in further view of Lieberman et al. (Plasma Sources Sci. Technol., 11 (2002) pages 283-293).

The reference of Dhindsa describes an etch chamber where two RF signals are supplied to a cathode (figure 2) and provide control for plasma uniformity (figure 4) (page 3, paragraph 0035). The limitations of claims 1, 10, 11 and 12 have been discussed above.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to use the method of Dhindsa to control the uniformity of a plasma enhanced etched process because Dhindsa discloses such a method. As to the details of the plasma theory and models, the limitations of claims 1, 10, 11 and 12 have been discussed above.

Claim Rejections - 35 USC § 103

7. Claims 34, 35, 37, 38, 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dhindsa et al. (US 2003/0148611) in view of Lieberman et al. (Plasma Sources Sci. Technol., 11 (2002) pages 283-293).

Dhindsa discloses dual frequency is conventionally used in plasma semiconductor processing for uniformity in processing (etching), but is silent about energy distributions.

Lieberman teaches energy distribution for different frequencies have different spatial profiles.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to further improve the method of Dhindsa by determining the desired energy distribution and selecting the proper conditions in order to form a resulting energy distribution from two frequencies with complementing energy distribution profiles because Lieberman teaches energy distributions are frequency dependant. One of ordinary skill in the art would have been motivated to combine an effect which yields a center-low energy distribution with another effect yielding a center-high energy distribution in order to obtain a resulting substantially flat uniform energy or power distribution.

One who is skilled in the art would be motivated to optimize through routine experimentation of power ratio between the two RF signals. See MPEP § 2144.05 (II)(B).

Claim Rejections - 35 USC § 103

8. Claims 36 is rejected under 35 U.S.C. 103(a) as being unpatentable over Dhindsa et al. (US 2003/0148611) in view of Lieberman et al. (Plasma Sources Sci. Technol., 11 (2002) pages 283-293) and Georgieva et al. (Journal of Applied Physics, V. 94, No. 6, Sept. 15 2003, pages 3748-3756).

Dhindsa discloses providing 2 MHz and 27 MHz simultaneously by a dual frequency source, but Dhindsa is silent about 13.56 MHz.

Demaray discloses 13.56 MHz, 100 to 400 KHz (page 5, paragraph 0043) and 2 MHz frequencies (page 11, paragraph 0086) are conventionally used in the art. It is noted that Demaray fails to disclose 13.56 MHz and 2 MHz on the same electrode.

The references of Georgieva (27 MHz and 2 MHz) and Lieberman (13.56 MHz and 40.7 MHz) teach energy distribution variation from one frequency to another are not limited to any combination of frequency such as 13.56 MHz and 100 to 400 KHz.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to modify the method of Demaray to obtain higher uniformity by mixing 13.56 MHz and 2 MHz on the same electrode for applications not requiring high ion bombardment because Demaray teaches the highest ion bombardment is obtained at the lowest frequency and Georgieva along with Lieberman teach different frequencies have different energy distributions. One of ordinary skill in the art would have been motivated use the teachings of the three references above to arrive at a proper frequency combination while utilizing commercially and readily available RF power generators. One who is skilled in the art would be motivated to optimize through routine experimentation of frequency mixing using commercially available RF power supplies. See MPEP § 2144.05 (II)(B).

Response to Arguments

Applicant's arguments filed on 9/5/2006 have been fully considered but they are not persuasive.

(a) *With respect claims 1, 14 and 34-39,* Demaray discloses that the plasma process chamber uses dual frequency one at higher frequency (13.56 MHz) and the other at lower frequency from 100-400kHz, and for any given deposition, the low frequency power is from about a tenth to about three quarters of the high frequency power. The high frequency accelerates electrons in the plasma, which is not efficient at accelerating the much slower heavy ions in the plasma. Adding a slow frequency, according to Demaray causes ions in the plasma to bombard the film being deposited on the substrate, resulting in sputtering and densification of the film. In the plasma chamber the first and second frequency RF power signals are involved in a dynamic process to optimize the characteristics of the plasma and hence the deposition or etch conditions (paragraph 0043). The applicants do not disclose in any of the claims the actual values for the first and second frequency for the source signal, which is important parameter in any plasma process.

(b) *With respect to claim 2,* Demaray discloses that the plasma characteristics controlled by the interaction of the first and second RF signals results in sheath modulation (paragraph 0047). The sheath formation in the chamber is due to application of bias to the substrate, which is akin to the effect of adding the low frequency RF power to the high frequency power to the source.

(c) *With reference to claim 10,* Demaray discloses that using the first and second frequency RF power in the plasma and modulating the flow of charge carriers would control the power distribution within the plasma (paragraph 0043).

(d) With reference to claims 11 and 12, applicants' arguments asserting that the combined reference of Demaray and Georgieva do not reveral all the limitation of claims are not persuasive. In fact, Georgieva presents extensive simulation results of the potential and electric-field distribution in the single and dual-frequency regime (Figs. 2 and 3, page 3751). The maximum and minimum values of the potential at the driven electrode in the dual-frequency regime are almost twice as large as those in the one-frequency regime for the same applied voltage amplitude.

(e) *With reference to claims 13 and 33,* arguments asserting that the combined reference of Demaray in view of Georgieva and Lieberman are not persuasive. Georgieva discloses that the interaction between first and second RF signals is used to control the characteristics of plasma and the film formed in the chamber (paragraphs 0043, 0045).

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is

filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Maki A. Angadi whose telephone number is 571-272-8213. The examiner can normally be reached on 8 AM to 4.30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nadine G. Norton can be reached on 571-272-1465. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service

Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dr. Maki Angadi
Examiner
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SHAMIM AHMED
PRIMARY EXAMINER